URBAN INFORMATION SYSTEM

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0. Introduction

The application of techniques of Operations Research to city planning has given rise to many controversial issues. The role of urban information systems in planning is one of them. Apart from the theoretical reasons stemming from the approach to planning, the practical reason giving rise to controversy over urban information systems is their costs, which are, more often than not, exorbitant.

An attempt is made in this paper to examine the role of urban information systems in light of the planning process and the relationship between theory, model, and data. A model which would help assess the cost-effectiveness of an integrated urban information system is also proposed.

The last section investigates the significance of the role of the urban information system in the planning and development of a New City.

1. Planning Process:

The planning process, as developed in this century, could be described in three steps.

(1) Understanding the past and present to anticipate the future;

(2) Distinguishing the components of the future status of the urban system as desirable and undesirable; and

(3) Suggesting and following a course of action which would increase the probability of a desirable future state and decrease the probability of an undesirable future state.

The importance of information in the first step of this process was realized long ago (Patrick Geddes). However, in the early days of the development of the planning process, systematic information, was almost non-existent. The earlier planning efforts, therefore, had to resort to ad hoc surveys. These ad hoc surveys, however, failed to help anticipate the future, due both to non-availability of time series data and to the then existing statistical methods. Such surveys did not even complete the first step and their influence on second and third steps could hardly be perceived. This perhaps led McLaughlin[1] to remark, "Worst of all, many plans seem to bear little if any relationship to these great catalogues of information; it is almost as if survey or information collecting was a kind of ritual behavior, an appeasement of some planning god to ensure his blessing on the plan itself; but how the word is made flesh (as the survey into a plan) is a mystery too deep to be plumbed". The recent developments in statistical methods such multivariate analysis have helped to achieve considerable progress in step one.

The planning process described in these three steps, however, has two underlying presumptions:

(1) It is legitimate for planners to decide the goals for the people of the city as a whole.

Although this is a very debatable presumption, it is the basis for all planning and would not, therefore, be argued in this paper.

(2) Having decided the goal, it is possible to <u>design</u> a course of action which would lead to these goals.

Even the proponents of "planning as a continuous process" apparently did not question the validity of this sequence. Seemingly what they implied was the repetition of the same sequence at smaller intervals. This dualism of ends and means came to be criticized in the last decade. Guttenberg,[2] in advocating tactical planning, pleaded, "For the planner, tactical planning requires a shift of focus from ends to means". He distinguishes goal plan from tactical plan. The goal plan, according to him, has the ability to persuade, to move people by its attractiveness, but it includes no explicit measures for ensuring that these goals are realized. The tactical plan, on the other hand, has a special purpose to prevent the objectives from being left behind by events over which planning has only limited control, events largely determined by innumerable decisions of private individuals. (Guttenberg, 3). The need for information is even more acute for such tactical planning than for goal plans. This is why the observed failures of planning are failures to plan five, three or even one year in advance, not failures to plan twenty-five or ten years in advance. (Simon, 4)

The other extreme reaction to ends-means dualism is expressed by Charles Lindblom and Karl Popper (Webber, 5). They contend that the only possible and the most effective way of planning is 'disjointed incrementalism'. This school of thought insists that instead of adjusting means to ends, ends should be chosen that are appropriate to the available means. The concept of planning implied by this line of thought is also quite distinct. It is argued that analysis and policy making are remedial; they move away from the ills rather than toward known objectives.

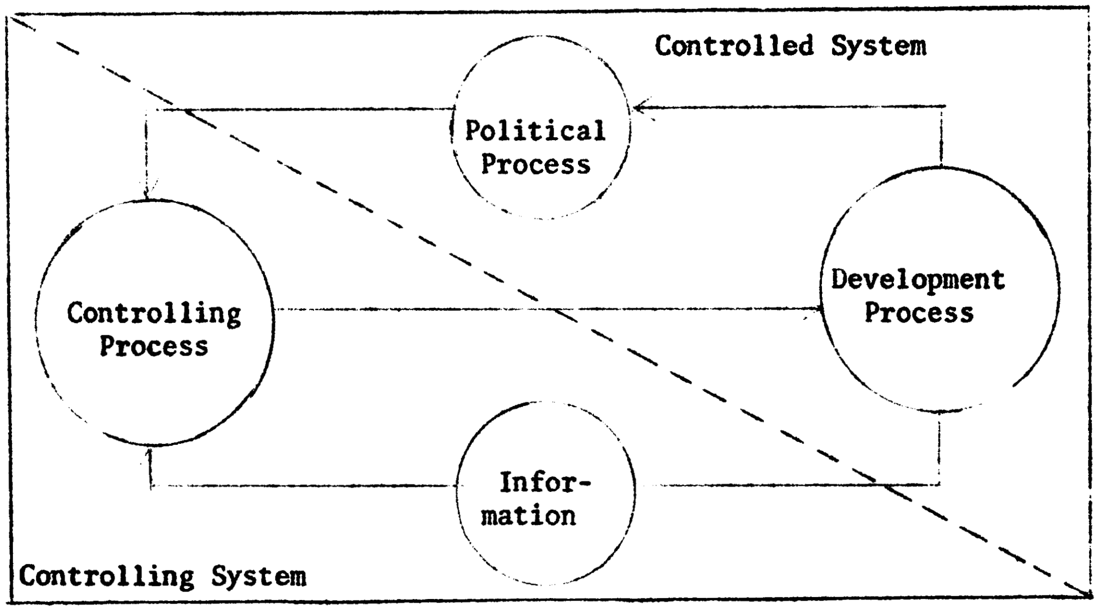
Such diverse reactions to planning theory stem from either of the following two basic presumptions.

(1) It is legitimate for planners to decide the long range objectives for the society, and planners have sufficient control over the means to achieve these objectives. It is therefore appropriate and possible to design means to achieve predetermined objectives.

(2) Planners have no right to decide the goals for the society at large. Their job is to remedy the ills perceived by the society and society grants them control over the means which are pertinent to the solving of these perceived problems.

Fortunately, however, the situation in the real world (at least when the spatial context of planning is sub-national) is between these two extremes.

It would be appropriate in conceptualizing the planning context, following Hermansen[6], to consider the role of information in the planning process. Furthermore, following McLoughlin[7], the environment could be conceived as a system and its control as an application of cybernetic principles. The planning environment could be conceived as having two sub-systems. The controlled system, though partially controlled by the controlling system, has some degree of independence. It possesses certain development processes, normally characterized as market forces, which do not yield to the controlling forces. The controlled system also possesses a mechanism through which it can not only express its responses to the controlling system but can influence the very nature of the controlling system. This mechanism may be termed the 'Political Process'. The controlling system has the controlling process as its main constituent. The means available for controlling the development process (or steering it to desirable goals) are defined by the political process. However, to apply the controlling tools the controlling system needs information about the state of the controlled system and the development processes within it. This could be diagramatically shown as:



With this framework, the discussion may return to the question of setting up long-range goals and tactical planning. The framework outlined above would lead one to conclude that the degree to which long range goals could be set up would depend upon the means that are placed at the disposal of the controlling process by the political process. For short-run purposes a method which decides the 'ends and means simultaneously' will have to be employed. It is here that the 'information' about the development processes will be of vital importance.

In this tactical planning, information performs four important functions. It helps (1) to describe the state or pattern of events; (2) to probe the relationship of events, their systematic structure; (3) to forecast future changes; and (4) to formulate ways to influence events. (Holleb, 8) It may be appreciated that the last purpose is the key to tactical planning or cybernetic control of the system.

What information needs to be selected, however, depends upon the theories which explain urban phenomena. Information by itself is not intrinsically useful in planning. The utility lies in understanding processes and aspects of urban phenomena, which is not possible without a theory and model. This relation between theory, model and data is discussed in the next chapter.

2. Theory, Model and Data

The need for adequate data has been felt by researchers and practitioners alike, in the field of urban studies. This is well represented, in the field of research, by Edwin Mills[9] when he was impelled to conclude his research on 'urban land values' with a note, "No economist can work long on urban matters without acquiring a strong sense of inadequacy of available data". This may be true for all other disciplines concerned with urban matters. An elaborate practical study remarked on the availability of adequate data in the following words: "The bringing of the BASS Model to its present level of operating performance has required the construction of an *ad hoc* data system specially designed for utilization of these models. Unfortunately, portions of the data used in the BASS models leave much to be desired in both quality and detail".[10]

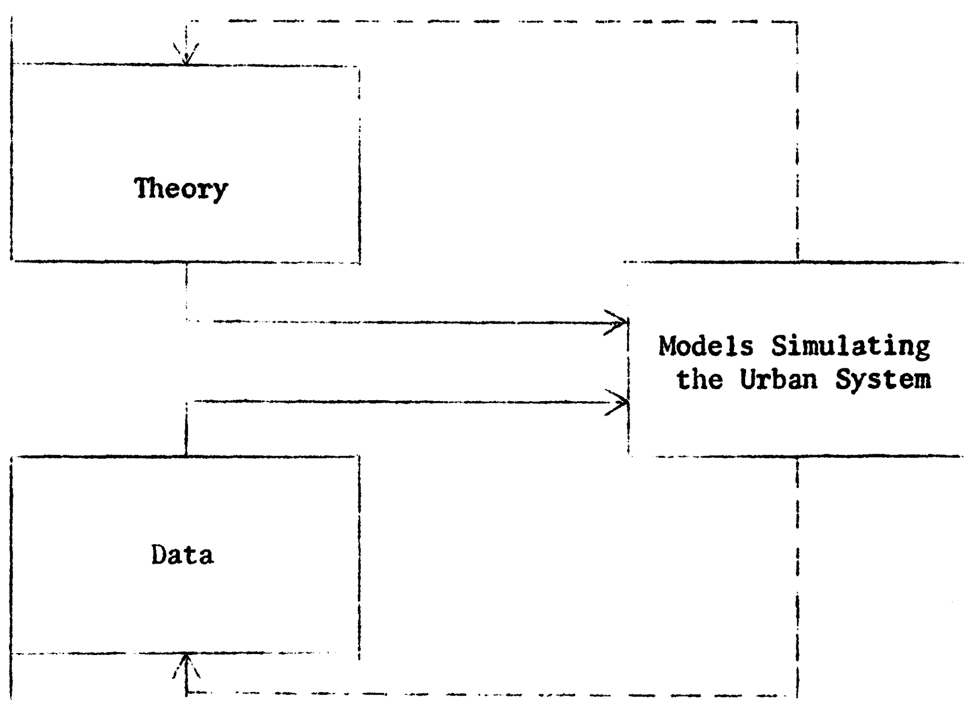
In order to evaluate the importance of information, it would be essential to investigate the relationship between "theories, models and data". Britton Harris[11] and Ira Lowry [12] both have attempted to draw distinctions between theories and models. The kernal of their discussion is that the theories of the urban system, though logically rigorous, are not easily testable since the urban system is inaccessible to experimental manipulation. However, when operational or mission-oriented models incorporate the logical structure of the theory with a view to 'replicate' the urban system, they demand certain data or are forced to accommodate the existing data.

This distinction is well exprssed by Harris who defines a model as an experimental design based on a theory. The attempts to calibrate the model, besides serving the mission, have two important payoffs.

1) They indicate the type of information that could be fruitfully utilized under the given theoretical development.

2) They also indirectly test the theory and help reveal shortcoming or anomalies of the theoretical construct of the urban system.

The relationship between theories, models and data could now be diagramatically shown as:



where continuous lines indicate the essential function of models, i.e., processing existing data in light of existing theories to simulate urban systems; and the broken lines indicate the pay-off of this process in improving both theories and data base.

It can thus be appreciated that the effectiveness of improvement in the quality of theory, model or data in terms of improvement in the quality of decision making about urban matters cannot be evaluated individually. The interdependence of these three factors has been well recognized by the scholars in the field. Britton Harris, concerned more with the quality of theory, advocates that the work should be organized on a scientific rather than a mission-oriented or technological basis. He also recognizes that in a laboratory for social engineering and planning research, the experimental material would be extensive data about metropolitan areas. The experimental design would be a model based on theory, using experimental material (data) and experimental tools (computer and software). William Alonso [13] on the other hand is concerned more with the quality of the (output of) models . In discussing the quality of the output of models he recognizes that errors may occur not only due to errors of specification (imperfect theory) but also due to errors of measurement (imperfect data). He therefore strongly advocates construction of models which take into account the quality of data available. Similarly the importance of guidelines which are provided by attempts at operationalizing the models and theory building for collecting data has been realized. The concern about such guidelines has been expressed by Hirsch[14] in the following words "Statistical agencies will drag their feet in the development of needed data if no guidelines for collection are provided". It should be appreciated that advances in the final quality of the decision in one of the three determinants, viz theory, model and data, in isolation of the other two is not going to be a very fruitful proposition.

It would now be appropriate to have an overview of information systems keeping in mind their interdependence with theory and models. Broad-based research and experimentation in the field of urban information systems took place in the decade of the sixties, resulting in four different approaches to urban information systems: 1) Housekeeping; 2) Data bank; 3) Model building; and 4) Systems approach.[15]

Housekeeping Approach: In this approach, data from highly routine operational tasks came to be processed by automatic data processing equipment. Each information system was limited to a specific task (e.g., water billing and payroll), of a particular functional department. This was not an information system in the strict sense of the term, but was only an automatic data processing system. Its purpose was limited to speeding up routine administrative procedures. The system was not organized to throw more light on the complexities of urban phenomena, with the result that it was of little use in planning or policy decisions.

Data Bank Approach: Encouraged by the limited success of the housekeeping approach and the enormous abilities of the digital computers, a very ambitious approach emerged. In this approach a data pool or bank would be established. Participating agencies would deposit data in this bank and would keep it updated. The data would be available, with the help of a generalized programming language, whenever required. An underlying hope in this ambitious effort was that the existence of extensive data itself would give rise to better policy decisions. This was, unfortunately, not true, and naturally received severe criticism. Siegel[16] wrote, "It is hard to go from an information system to a program. Although this point may appear obscure, I believe that it is responsible for a notable lack of success some economists have had in selling state and local governments on regional income and product accounting information systems. These systems would have been indispensable if they were, for example, part of an economic stabilization program. But state and local governments do not have much to do in the way of economic stabilization and, therefore, have little need for the information furnished by a regional income and product account information system. The same may be true of comprehensive data banks. An offer to collect, store, and make quickly available the information now collected by everyone does not excite anyone enough to put his funds to work for the purpose. A focus is needed for data collection; a system of public programs provides this focus". In this, Siegel is stressing importance of purpose for data collection, whereas Melvin Webber[17] in his eloquent remarks on data banks emphasises the importance of theories which explain the phenomena, ". . . But which characteristics should be monitored depends upon the theoretic formulations we believe best explain the working of the systems they belong to and best reflect the valuative preferences that deciders hold to. In this light it is becoming apparent that many of the new data banks are little more than grab-bag collections of data for which no theoretic base exists. Like the drunk who was searching for his lost keys under the lamp post because the light was better there, many of the new data banks seem to be storing data just because these specific numbers happen to be easy to get".

Model Building Approach: The conceptualization of urban phenomena needed to be tested before it could be used in problem solving missions. For this testing of theories, models were built as experimental designs. These experiments needed large amounts of data. Data required by these models were almost non-existent. The model building campaigns therefore had to build their own ad hoc information systems. These efforts, however, had a serious limitation of having cross-sectional bias, i.e., the information they gathered and processed was for one point in time. They, therefore, missed the finer aspect of intertemporal changes in parameters. Since the data were collected on an ad hoc basis for a particular mission, the cost of their collection and processing accounted for significantly large proportions of the total budget, i.e., around two-thirds.[18] Information systems developed for models were generally unrelated to administrative and managerial procedures of city governments. Moreover, model builders failed to be concerned with using governmental operational activities to keep data current. Thus, the overall benefit of the information systems built for single-purpose and one-time use of a model has been small in terms of the tremendous cost of initial data collection, processing, and analysis.[19] Presumably one of the important reasons for the shortcomings of the model building approach was that most of the model building efforts were undertaken by consultants. The consultants had time and budget constraints and moreover their responsibility was limited to a particular task

Systems Approach: The deficiencies of these approaches led to what could be termed as the systems approach. The housekeeping approach made it clear that computers have far greater capacity than that required for speedier computations that could be utilized in planning endeavors. The data bank approach made it abundantly clear that the mere existence of data (without concomitant development in theories) is unable to influence the quality of decision-making. Or in other words, invention failed to mother the necessity. The model building approach revealed two important factors: firstly, the information about the urban situation cannot be meaningfully conceived as stocks at a given period in time, but needs to be considered as flows continuously observed in time; secondly, information systems cannot be economical if developed for a single purpose.

The urban information system developed with a systems approach could be characterized as follows:

1) The information system is organized for a defined purpose, which may desirably have multiple objectives.
2) Only those elements of data are collected and stored in the system which in light of the available theories, help describe, explain or predict urban phenomena and hence influence policy decisions.
3) Since the information is conceived as flows and stock to be observed continuously, the collection of data is related to day to day administrative, legal, and political procedures.

Such an approach would however raise two theoretical questions. One, "system" by definition implies that each element is related to every other element. Under such circumstances how could the boundary of an urban information system be decided? Second, the purpose of planning as well as theories of urban phenomena change over time and may therefore demand different data. How could the elements of the data base therefore be decided? The answer to the first question is more formally attempted where the cost-effectiveness model for information systems is discussed in Section 4. The second question shall be dealt with in section 3 where the 'design' of information systems is discussed. The "information system", for the rest of this paper, shall imply the one described by the term "systems approach".

3. Design of Urban Information Systems:

The content of an information system, it may be argued, based on the previous two chapters, depends upon the purpose or objectives it is supposed to serve under a given planning process and the theories which describe, explain, or predict the urban phenomena. This implies that selectivity rather than comprehensiveness is the essential feature of information. What to omit is as significant as what to include.[20]

Relevance to the purpose or to policy formulation and relevance to theories that explain the phenomenon with which the policy is concerned are key guideposts of selecting the information. In building an information system, it is necessary to distinguish between the flows of information that are really significant to the planning process and those that are peripheral, those that may be indicators of basic processes of change as distinguished from those which principally serve management needs. Prior analysis of information flows in terms of their potential significance for policy questions is essential to avoid indiscriminate storage of useless data.[21]

This point is of special importance in light of the enormous abilities of computers to deal with the proliferation of machine-readable information. Perhaps this prompted the Systems Development Corporation to emphasize that the objective of an urban information system should be to provide for direct support of multiple mission-oriented programs such as urban renewal, transportation planning, hospital planning and so forth, as contrasted with 'data banks' in search of users.[22]

The task of determining the information needs could be accomplished by what may be termed as systems analysis. Systems analysis is basically concerned with developing knowledge and understanding about an existing system. The system is decomposed into its parts to facilitate analysis. This decomposition is followed by a synthesis in which a new or changed system is formulated.[23]

The process of systems analysis can be conceptually described as follows:

(1) Assess the information used by each of the component parts of the system. The informational requirement may be translated in the form of a) entities about which information is required, e.g., housholds, parcels of land; b) the attributes which are essential to describe the entity, e.g., household income, location of parcel; c) the level of disaggregation or resolution at which the actual data value is recorded (e.g., if the income of a household is recorded as an actual figure the degree of resolution may be 100%, but if it is recorded in terms of classes of intervals such as low, medium, high; the degree of resolution may be lower than 100%.). The scale of degree of resolution is an abstract but useful concept.

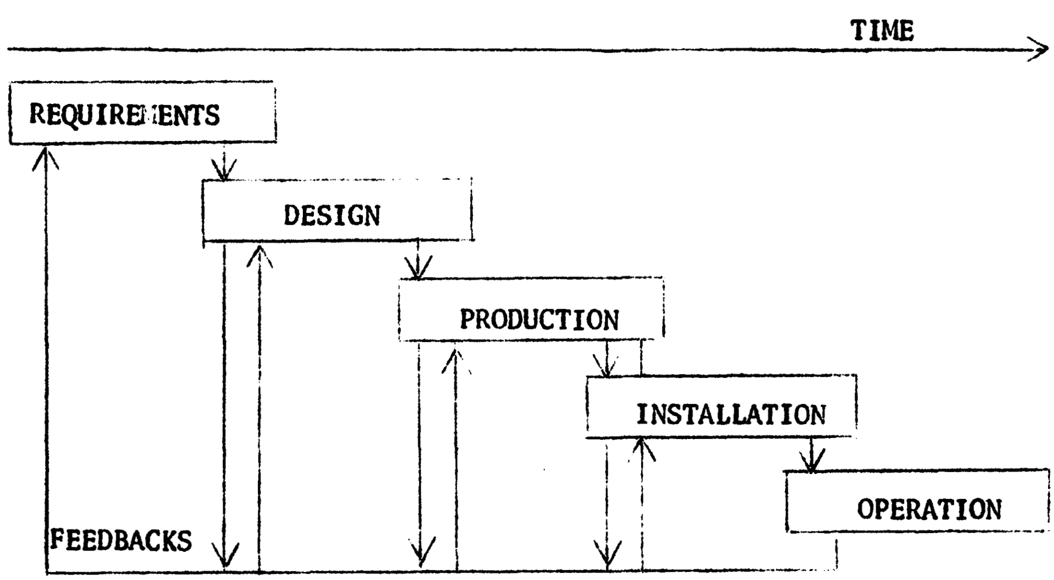
(2) The purpose of systems analysis is not just to know "what is" but also to lead to "what should be". To decide "what should be", the following questions may be asked about the "what is" analysis, in light of the available theories: a) Are all the entities, about which information is said to be required, relevant to the mission of the

concerned components? b) Are all the attributes that are supposed to describe the entity really meaningful in their content? Do they sufficiently describe the entity? c) Is the degree of resolution of information-recording optimal?

The answers to these questions may reveal that in some cases prescribed information is redundant and in some cases new information could be meaningfully incorporated due to improved theories and analytical procedures.[24]

Deciding information requirements in this fashion raises an important question. How can informational requirements be decided only in light of today's purposes and theories when both are continuously changing over time? This is the question which Edward F. R. Hearle was referring to, when he advocated for the "information availability" approach in building the information systems as against the "information requirement" approach in 1963. He went on to describe the information availability approach as building a data system to integrate the collection and storage of data and to make them readily accessible without worrying a great deal about what the user does with them.[25] Unfortunately, however, experience in the last ten years shows that such data banks have not found sufficient users to justify their cost. (Webber 1965, Siegel 1968, Kraemer 1970)

An eloquent reply to this question can be found in the principle which Lindblom enunciates. "The objective in making predictions and projections into the future is to provide a basis for the decisions that are to be taken today; tomorrow's decisions can and should be made on the basis of information available tomorrow."[26] A less eloquent reply to the question would be that it is not economical to collect and store information that would be useful only with certain probable changes in theories and purposes of planning. It would, however, be important to design the information systems with enough flexibility so that additional information could be incorporated as and when required without any structural changes in the information system. Or in other words, development of the information system itself needs to be conceived as a continuous process parallel to the planning process. The various phases of this process could be termed as requirements, design, production, installation and operation for conceptual clarification. It may, however, be appreciated that there is a feedback between two consecutive phases and the phases occur in a cyclical fashion. This can be digramatically indicated as follows.[27]



How precisely such a flexibility could be achieved is dependent largely upon the technology and especially upon the hardware that is available and software that could be developed. However, this issue has been kept outside the perview of this paper and is, therefore, not discussed further.

Planning and Administrative Uses of Information:

Although planning and administration in urban affairs lie on the same continuum, the ways in which they use information differ significantly. The administrator is more concerned with the actual data which indicates the stocks precisely, on the other hand a planner is more interested in inferring the nature of processes that shape and are likely to shape urban life. This can be illustrated by an example. The property record maintained by a tax administrator provides him with exact details about the stocks of properties so that he can assess and collect the taxes. On the other hand the same record appears to the planner to be an indicator of trends of how the real estate market has been behaving over a period of time or of what is the pattern of spatial distribution of various land uses and how it has been changing. It may be observed that much of the data needed for planning can be acquired from data that are needed for other administrative operations. Making a deliberate attempt to use the data that originates from these administrative operations is extremely important in view of the high cost of data collection. Furthermore, data required for administrative purposes have concrete and definite uses, and they can be updated more easily through administrative procedures which can be used or adapted, to provide data needed for planning.[28] This precisely is the task which systems analysis is supposed to accomplish.

Time Path of Development of an Urban Information System:

The limitations on the state of theoretical understanding of urban phenomena and the significantly high cost of data suggest a strategic approach to development of an urban information system. Urban information systems are best built from the ground up, starting with existing needs, systems and activities. A single 'comprehensive system' should be viewed as an outcome rather than as starting point. From this perspective, the handling of administrative records and operations appear to be important components, for they are two activities likely to secure early support and early success. There is good reason, therefore, to begin with administrative, operations, and control systems, developing them as individual systems. and then phasing in management, planning and research information systems - probably in that order.[29] Planning is usually meant to imply a process which heavily leans on goal-seeking activity. There exists, however, what is termed tactical planning which deals with day to day decisions and actions which are taken in light of the goals. This tactical planning directly needs the information that could be collected and may use it meaningfully. The goal setting process, however, goes beyond the things that are represented by the data. It deals with more abstract things like societal aspirations or quality of life. Information systems cannot be of much use unless theories, even in hypothetical form, are developed to plausible levels which can help interpret the data in this respect.

The strategy of developing the urban information system from the ground up is significantly important where the hardware is costly and knowhow in software is not well developed. This strategy ensures concrete usage of the information system as it is developed and therefore also avoids unduely heavy investment in the beginning.

4. Cost-effectiveness of Integrated Urban Information System

Prelude to Cost-effectiveness Model:

The benefits of an information system can be rigorously evaluated only in terms of the improvement in the quality of decision-making and consequently in that of the final output. However, empirical material or empirically-based hypotheses seem to be inadequate in this area.[30] Ambitiously rigorous cost-benefit analysis is therefore not attempted. On the other hand, a cost-effectiveness analysis is proposed, which is preceded by a systems analysis phase described earlier.

The systems analysis decomposes the environment, in which the urban information system is supposed to function, into various components. The information needs of each component or function are decided in light of available theories and analytical procedures, and a possible planning process. This analysis presumably decides the information that is optimal, i.e., the total stock of data neither contains any redundant information nor is it deficient in potentially useful data.

There are two alternatives available to handle these informational requirements:

1. The required data may be collected and stored by an individual component.
2. The data may be collected and stored in one integrated information system from which they may be retrieved by various components.

The first alternative is not an information system in the stricter sense of the term. Since the information utilized in both the cases is assumed to be the same, the benefits occuring due to the usage of information may also be assumed to be same.

The cost-effectiveness analysis therefore conceptually compares the costs of these two alternatives.

<u>Model for Cost-effectiveness Analysis of Urban Information System</u>

0.0 Basic Assumptions

0.1 The "city planning and administration" has several "sub-functions". (e.g. housing, transportation, utilities, etc.)

$Fi \in CPA$ (i = 1, 2, 3 . . . n)

where Fi = sub-function CPA = city planning & admin.

0.2 Each sub-function (Fi) needs information about certain entities. (some of the entities for the sub-function "transportation" would be the network of highways and network of subways)

Eij = an entity j required by function Fi

0.3 Each entity has a certain number of <u>attributes</u> (entity "network of highways" has the attributes - no. of links and no. of nodes)

Aijk = an attribute of entity Eij of function Fi

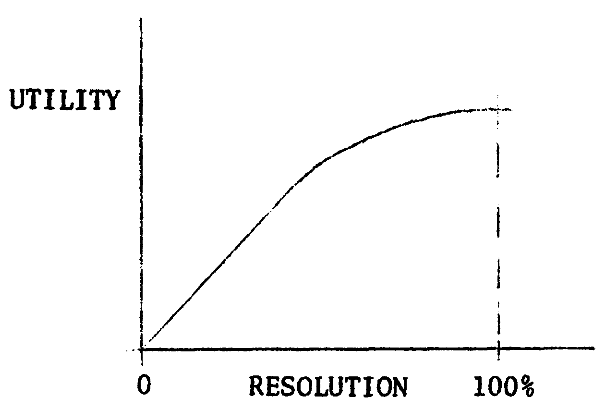
where k = 1, 2 . . . K, i.e. total number of

attributes of Eij will be ijK

0.4 Information about the attributes is recorded at a certain level of disaggregation or resolution (e.g., land use may be recorded either in very broad categories such as Residential, Commercial and Industrial or in very fine stratified classification resembling a 3 or 4 digit SIC classification)

Rijkl = level of resolution of information recorded for attribute Aijk of entity Eij of sub-function Fi

Rijkl assumes values from 0 to 100%. The level of resolution could be considered equivalent to 100% where further disaggregation would not bring about meaningful information for a given function. (Recording lot sizes in feet and inches may be meaningfully maximum (100%) level of disaggregation, recording in yards only would be less than 100%, but recording to the 100th of an inch would be simply meaningless.) This is rather abstract but useful concept since the utility of informational fineness depends upon the development of theories which explain a given phenomenon.



The cost-effectiveness of the integrated information system is proposed to be derived separately for the following components of the cost:

1. Data Collection and storage,
2. Data Retrieval, and
3. Updating of data.

1.0 Cost of Non-integrated Information: Collection and Storage

1.1 Assumptions:

1.1.1 There is no interfunctional flow of information.

1.1.2 The cost of intrafunctional flow of information is nil.

1.1.3 Spatial coverage for information collection for all entities and attributes is the same.

1.2 Cost per entity:

The cost of information collection and storage for an entity would be conceived to depend upon the number of attributes of the entity and the level of disaggregation at which information is recorded for each attribute. The level of disaggregation being expressed as a percentage, it is necessary to convert into absolute quantities (e.g. bits) for arithmetic manipulation. The function that converts the level of disaggregation may be expressed as f(Rijkl)

Formally,

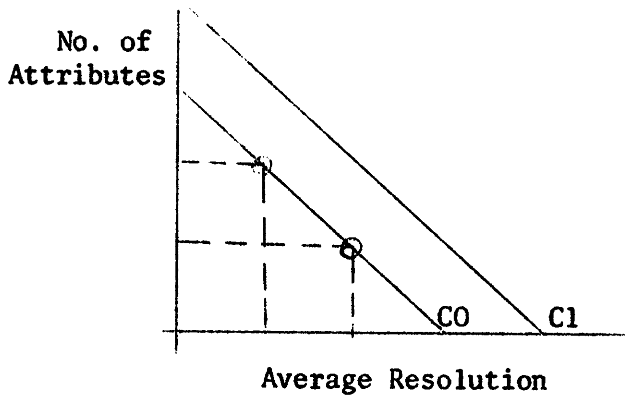
$$C(Eij) = C(\sum_{k} f(Rijkl))$$

or if we define the "average level of disaggregation" (ARij) as,

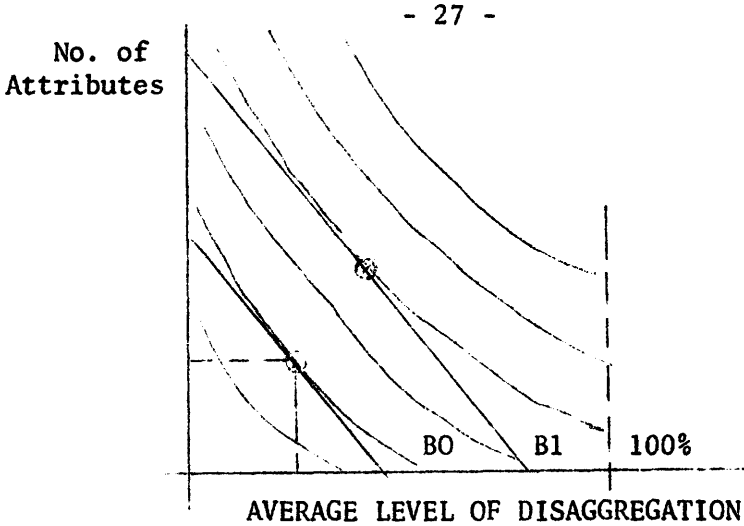
$$ARij = f(\sum_k Rijkl) \big/ ijK$$

and also assume a linear relationship between the cost for entity (Eij) and ijK and ARij, the cost could be expressed as

c(Eij) = c(ijK + ARij) where 'c' indicates the cost function



1.3 Digression: The above concept could be interpreted in a slightly modified form. Number of attributes and average level of disaggregation could be considered as substitutable factors of a utility (informational) function. Indifference curves between the two factors could be drawn constrained by the 100% level of disaggregation. A budget feasibility line would then decide the optimal combination of the two factors.



1.4 Spatial Coverage: Spatial coverage, especially in urban information systems, forms an important factor affecting the cost. Not all the entities require information over the entire area of the city (e.g. urban renewal). This fact could be judiciously used to control the cost. We may therefore relax assumption 1.1.3.

Sijkp = spatial coverage for information collection of attribute Aijk of entity Eij of function Fi, expressed as percentage of the total city area.

It should be noted that spatial coverage along with level of resolution would determine the absolute number of bits required for each attribute. Assuming a linear relation between the number of bits for Aijk(NBijk) and Rijkl and Sijkp, it may be stated that NBijk = f(Rijkl + Sijkp). Average number of bits per Aijk (ANBij) could now be defined as

$$ANBij = \sum_{k} f(Rijkl + Sijkp)/ijK$$

$$= ARij + ASij$$

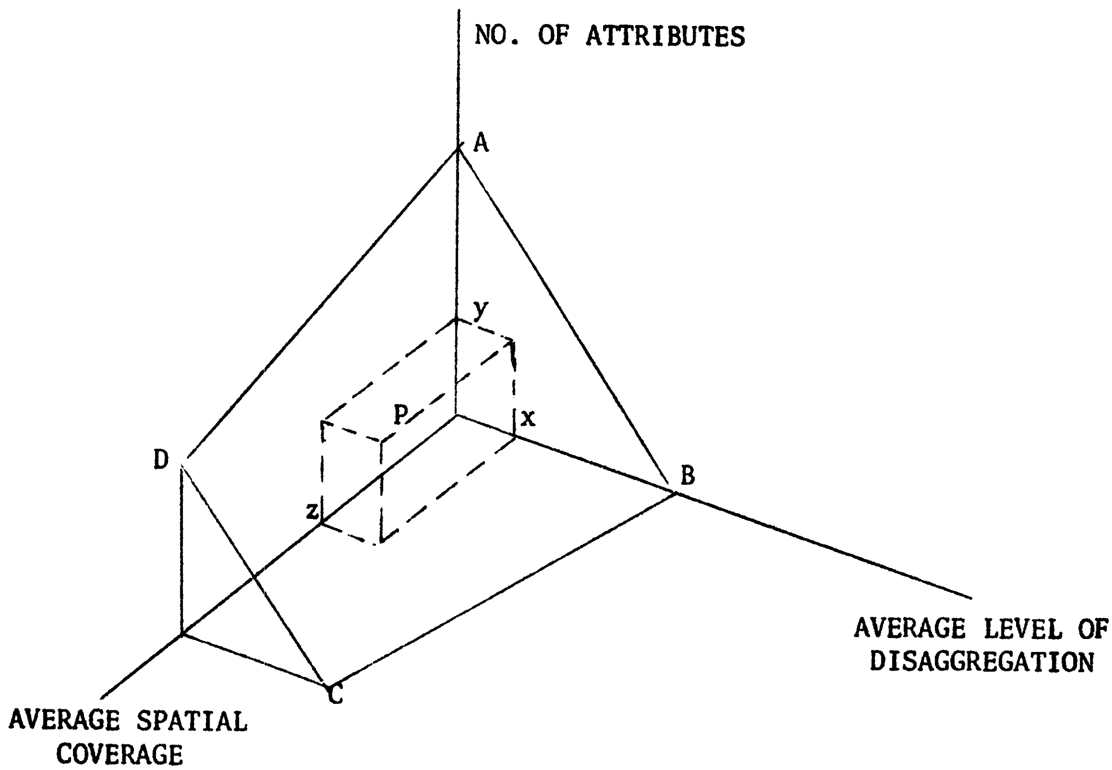
where ASij means average spatial coverage for Aijk

Assuming a linear relationship between the cost of Eij and ANBij, it can be stated

$$c(Eij) = c(ijK + ANBij)$$

$$= c(ijK + ARij + ASij)$$

This could be graphically represented as



Plane ABCD indicated the possible combinations of the three factors for a given budget constraint, BO. Point P on the plane, for example, indicates x, y and z as the possible combination of average level of disaggregation, number of attributes and spatial coverage respectively for budget constraint BO.

1.5 Total Cost:

The cost of information collection for function Fi will therefore be

$$c(Fi) = \sum_j c(Eij)$$

and the total cost (TC) for the city will be

$$TC = \sum_i c(Fi)$$

2.0 Cost of Integrated Information System: Collection and Storage

The non-integrated information system described in the last part assumed that there is no inter-functional flow of information. This, however, implies that there is duplication of information collection since in reality many functions require information about the same entity (although perhaps at different levels of disaggregation or about different attributes). This overlapping of informational requirements is the fundamental reason for the advocacy of an <u>integrated</u> information system. An attempt is made to formulate a model to assess the cost-effectiveness of such an integrated information system.

2.1 Assumptions

2.1.1 An integrated information system implies addition of a new sub-function (Fn + 1) to city planning and administration.

2.1.2 Information required by various functions about the same entity contains the same number of attributes at the same level of disaggregation and for the same spatial coverage.

2.1.3 The cost of flow of information from $(F_n + 1)$ to $F_i (i = 1 \ldots n)$ is nil.

2.2 $E_{ij} \notin F_i$

However, it is possible that E_{ij} F_j. Under such situation the total cost of integrated system would be

$$TCI = c(\bigcup_{i}^{n} F_i)$$

the right hand side could be expanded as

$$c(\bigcup_{i}^{n} F_i) - c[\sum_{i=1}^{n} \sum_{j=i+1}^{n} (F_i \cap F_j) - \sum_{i=1}^{n} \sum_{j=i+1}^{n} \sum_{k=i+2}^{n} (F_i \cap F_2) \cap F_k)]$$

the saving in cost = TC-TCI

$$= c(\sum_{1}^{n} F_i) - c(\bigcup_{1}^{n} F_i)$$

This indicates that overlapping of informational requirements is the key factor deciding the cost-effectiveness of an information system.

2.3 Digression: The degree of overlapping of informational requirements, though it decides the cost effectiveness of information system is exogonously decided particularly by the stage of development of (planning) theory and the approach of the planner. A few decades ago, origin-destination survey was the only tool available for the transportation planner, but with the development of gravity models and the systems approach, a host of information like locational distribution of residences, work places, shopping areas, and household incomes becomes '<u>relevant</u>' to the transportation planner. It is obvious that this information is also required for tax collection, urban renewal, employment promotion programs, etc.

3.0 Assumption 2.1.2 and 2.1.3, in the last part shall now be relaxed. To deal with such a situation, however, the following further assumptions will be made.

3.1.1 Only aggregation of information is possible and not disaggregation.

3.1.2 Partial retrieval of information from the original spatial coverage is feasible but not the extension of the spatial coverage.

3.1.3 Information about attributes in sub-function Fn+1 will therefore be stored at the maximum level of disaggregation (max. of Rijkl) and maximum spatial coverage (max. of Sijkp), both the maxima being decided for individual Aijk. Since this information does not particularly belong to any function or entity, subscripts i and j will be dropped.

3.2 <u>Cost of Retrieval</u>

Cost of retrieval can be conceived as having two components:

A. Cost of aggregation

B. Cost of communication

A. Cost of aggregation would be directly proportional to the difference between the level of disaggregation at which the information is stored and the level of disaggregation at which it is required (Rkl - Rijkl). It would also be inversely proportional to the difference between the spatial coverage at which the information is stored and the spatial coverage at which it is required (Skp - Sijkp).

Cost of Aggregation

for $cl(Eij) = cl\left(\sum_{k} \frac{f(Rkl-Rijkl)}{f(Skp-Sijkp)}\right)$

for $cl(Fi) = \sum_{j} cl\ (Eij)$

for all $Fi(i=1,2,\ldots\ldots n)$ $CA = \sum_{i}^{n} cl(Fi)$

where 'cl' indicates the cost function of aggression.

CA indicates the total cost of aggregation.

B. Cost of communication would depend upon the volume of information and the frequency at which it is retrieved.

Volume of information = f(Rijkl x Sijkp)

Frequency = FRi, where it would be greater than the frequency of updating of information for function i.

Cost of communication

for $c2(Eij) = c2\left[\sum_{k} f\ (Rijkl \times Sijkp) \cdot FRi\right]$

for $c2(Fi) = \sum_{j} c2(Eij)$

for all $Fi(i=1,2,\ldots\ldots n)$ $CC = \sum_{i}^{n} c2(Fi)$

where 'c2' indicates the cost function of communication

and CC indicates the total cost of communication

4.0 Part 2.0 and 3.0 could be synthesized as follows:

Saving in cost due to integrated system

= TC-TCI+CA+CC

= TC-(TCI_CA_CC)

= TC-[TCI-(CA+CC)]

For saving in cost to be positive

$(CA+CC) < TCI$

(for $CA+CC = TCI$ saving = 0; and

$CA+CC > TCI$ saving < 0.)

4.1 Fixed Cost: The discussion so far has been concerned with variable costs mainly dependent upon volume of information. The saving in fixed costs due to integrated systems would be significant especially when "Automatic Data Processing" is resorted to in both non-integrated and integrated information systems.

If we denote x = fixed cost per function in a non-integrated system

$n \cdot x$ = total fixed cost for non-integrated system

$x1$ = fixed cost for integrated system where

$x < x1 < n \cdot x$

4.2 Finally the cost-effectiveness function could be written as

$$\text{cost-effectiveness} = \frac{(n \cdot x + TC) - [(x1 + TCI) - (CA + CC)]}{n \cdot x + TC}$$

5.0 Digression: Conceptual organization of data:

We started with the description of a non-integrated information system which could be graphically shown as in Figure 1.

We then recognized the overlapping of entities in various functions. This could be indicated as in Figure 2.

We therefore decided to store information in function Fn+1 independent of Fi and Eij at the maximum Rijkl and maximum Sijkp derived from table 1 and now indicated as Rkl and Skp.

This could be represented as in Figure 3.

To retrieve information from such an arrangement, the demanding function will have to provide two matrices R and S. The rows of matrix 'R' will indicate the levels of disaggregation for various attributes of a given entity and the columns will indicate levels of disaggregation required for various entities for a given attribute. The row vectors of matrix 'S' will indicate the desired degree of spatial coverage by a given entity for various attributes and the columns of matrix S will indicate the degree of spatial coverage required by various entities for a given attribute.

Figure 1

		A1j1	A1j2	A1j3	..................A1jk
F1	E11	R1111 S111p	Rii21 S112p	R1131 S113p	..................R11k1 ....S11kp
	E12	R1211 S121p	R1221 S122p	R1231 S123p	..................R12k1 ....S12kp
	Eij	Rij11 Sij1p	Rij21 Sij2p	Rij31 Sij3p	..................Rijk1 ....Sijkp
		Anj1	Anj2	Anj3	..................Anjk
Fn	En1	Rnii1.. Sniip..			
	En2	....			
	Enj	....Rnjk1 Snjkp			

Figure 2

		A1j1	A1j2	Aijk...........................
F1	E11			
	E12			
F2	E21			
	E22			
F3	E31			

Figure 3

	A1	A2	A3.......................Ak
Fn+1	R11 S1p	R21 S2p	R31.......................Rk1 S3p.......................Skp

However, for such an arrangement to work effectively, every bit of information stored about an attribute will have to carry an "entity identifier" for each entity. This would increase the volume of information to inefficient levels. The question of entities and attributes needs to be reconsidered. It can be appreciated that the distinction between entities and attributes is rather artificial in the sense that it is not independent of the context. For example, in one context 'household' may be an entity and 'household income' may be its attribute in another context a 'block' may be an entity and 'number of <u>households</u>' may be its attribute. In other words, one of the attributes in one context could be selected to act as an entity in another context. With such an arrangement of data it would be possible to avoid having all the entity identifiers accompany every data item. This is achieved through what is technically known as an "<u>Inverted File</u>".[31]

6.0 Cost of Updating

6.1 So far the discussion has been concerned with the cost of initialing the data base, i.e., collection and storage of information, and retrieval of information. The data base, however, needs to be updated periodically. Two types of updating could be identified - (1) bench mark updating - or census - which would mean one hundred per cent updating could be widely spaced in time, e.g., a decennial population census. (2) Intermediate updating would imply updating between the two benchmark updatings. Since the cost characteristics of benchmark updating would be similar to those already discussed for initiating the data base, in this section we will only consider the intermediate updating.

6.2 The basic principle of updating would be "sampling". The sampling technique could be applied to two dimensions of the information per attribute, viz, level of disaggregation and spatial coverage. Information could be updated at a lower level of disaggregation and then further disaggregated in proportion to the original data base. Spatially too, information could be updated per stratified sample of spatial units (blocks) and then expanded to the universe. Cost of updating for an individual attribute would therefore depend upon the sample size of these two dimensions. Formally

$$u(Aijk) = u[(s \cdot Rijkl + S \cdot Sijkp)FRu]$$

where $u(Aijk)$ = cost of updating attribute Aijk of entity Eij of function Fi

S = the sample size expressed as percentage

u = indicates the cost function for updating

FRu = frequency of updating

Cost for an entity Eij:

$$u(Eij) = \sum_k u(Aijk)$$

Cost for function Fi:

$$u(Fi) = \sum_j u(Eij)$$

Cost for updating the non-integrated system:

$$TCU = \sum_{i} u(Fi)$$

6.3 The saving in cost of updating due to an integrated system could now be expressed, following similar notations as in 2.2, as the saving in cost of updating = TCU-TCIU

$$= \sum_{1}^{n} u(Fi) - \bigcup_{1}^{n} u(Fi)$$

6.4 Digression: The significant saving in cost of updating an integrated system would, however, occur due to the possibility of applying sampling techniques to an additional dimension of the data base, viz, number of attributes. This would be especially true if the data are organized as indicated in 5.0. Since in an integrated system all the attributes are pooled together, there is an increased possibility of selecting only the key attributes for updating and then expanding the information. This, however, is not formally expressed in the model.

7.0 Finally, the cost-effectiveness function for updating could be written as

$$\text{cost-effectiveness of updating} = \frac{TCIU-TCU}{TCU}$$

8.0 An Alternative Explanation of the Model:

8.1 Assumptions

8.1.1 Data are stored in the form of attributes only without explicity referring to the entities. (as already indicated in 5.0)

8.1.2 Functions retrieve data for required entities, but the volume of data could be measured in terms of attributes alone.

8.1.3 Resolution and spatial coverage which are known in the form of percentages can be converted into absolute quantities suitable for arithmetic operations. (e.g. 'bits')

8.2 Notation:

A = universe of attributes, $Aj \subset A$ where $j = 1 \ldots\ldots m$

Fi = subfunction i ($i=1 \ldots\ldots\ldots n$) of the city government

iAl - an attribute required by function i

iA = total attributes required by function i; $iA \subset A$

Rj - degree of resolution for Aj

Sj = degree of spatial coverage for Aj

$f(Rj+Sj)$ = function that converts Rj and Sj into absolute quantities

$c(Aj)$ = cost function for storage of information for Aj which is assumed to be equivalent to $c(f(Rj+Sj))$

8.3 Two Function Case

Let there be only two functions - F1 and F2

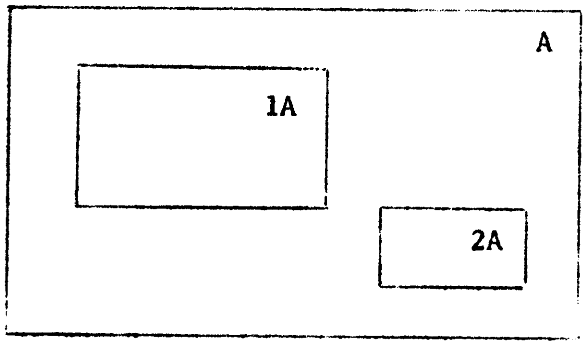
$1A \subset A$ and $2A \subset A$

$1Al$ where $l = 1, \ldots\ldots p$ and $p < m$

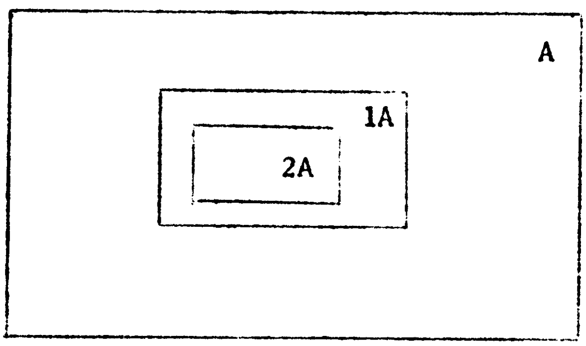
and $2Al$ where $l = 1, \ldots\ldots q$, and $q < m$

represent individual attributes required by F1 and F2 respectively.

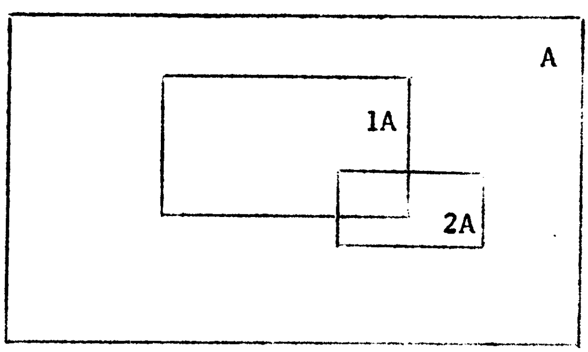
There exist three possibilities as indicated in the following Venn diagrams.[32]



POSSIBILITY 1



POSSIBILITY 2



POSSIBILITY 3

If the information is handled individually by each of the functions (non-integrated system) the total cost for the function (TC) could be expressed as

$$TC = c(1A) + c(2A)$$

$$\text{where } c(1A) = c\left(\sum_{l=1}^{p} 1Al\right)$$

$$= c\sum_{l}^{p} \left(f(1Rl+1Sl)\right)$$

In the case of an integrated system the total cost (TCI) for both the functions may have three possible values corresponding to the Venn diagrams shown previously.

POSSIBILITY 1

$TCI = c(1A) + c(2A)$ no saving

POSSIBILITY 2

$TCI = [c(1A) + c(2A)] - c(2A)$

POSSIBILITY 3

$TCI = [c(1A) + c(2A) - c(1A \cap 2A)$

or in general $TCI = c(1A \cup 2A)$

and $TC = c(1A+2A)$

The saving $TC\text{-}TCI = c(1A \cap 2A)$

The three possibilities are summarized below

POSSIBILITY	$1A \cap 2A$	SAVING
1	$\emptyset$	zero
2	2A	c(2A)
3	$\neq \emptyset$	$c(1A \cap 2A)$

8.4 'n' Function Case:

The argument could be extended to 'n' function case

$$TC = c\left(\sum_{i=1}^{n} iA\right)$$

$$TCI = c\left(\bigcup_{i=1}^{n} iA\right)$$

$$= c\left(\sum_{i=1}^{n} 1A\right) - c\left\{\sum_{i=1}^{n}\sum_{j=i+1}^{n} (iA \cap jA) - \sum_{i=1}^{n}\sum_{j=i+1}^{n}\sum_{k=j+1}^{n} ((iA \cap jA) \cap kA)\right\}$$

saving in cost due to integration may therefore be expressed as

$$TC-TCI = c\left(\sum_{i=1}^{n} iA\right) - c\left(\bigcup_{i=1}^{n} iA\right)$$

$$= c\left\{\sum_{i=1}^{n}\sum_{j=i+1}^{n} (iA \cap jA) - \sum_{i=1}^{n}\sum_{j=i+1}\sum_{k=j+1}^{n} (iA \cap jA) \cap kA)\right\}$$

Similar arguments could be made for the rest of the cost factors such as fixed costs, retrieval and updating costs.

5. Role of Urban Information Systems in Planning and Development of a New City.

The planning procedure that has evolved over a number of years and that is widely practised has been succintly described by Melvin Webber[33] ". . . This planning procedure revolves around sets of standards for sizes, locations, capacities and other physical dimensions of highways, school houses, water systems, library buildings and the like. In turn, it relies upon long-range forecasts of demand (sometimes called "requirements"), and upon professionals' judgments of desired future conditions. It results in the declaration of a design (or "plan") for facilities that conforms to those standards and judgments and matches the expected loadings."

Although this approach has been severely criticised, the analytical tools that have been developed and put into practice still revolve around what may be termed a "demand model". The explanations of urban growth based on the notion of "export-base" presumes that a given number of export workers 'supports' a given number of local service workers.[34] The existence of the service sector is assumed to be solely dependent upon the export sector. An exogenous forecast of production in the export sector then leads to the demand for the service sector and to the dependent population, which then forms a basis for the planning procedure described by Webber.

Operationalized models that are principally developed to describe the locational pattern of various activities also have an underlying presumption that location of certain (basic) activities can be exogenously decided. This is then assumed to dictate or demand the locational behavior of the rest of the activities.[35]

It is, however, possible to explain urban growth by accepting a "supply model". It has been argued that the so-called service sector is really the basic sector. It is more enduring and its potential "supply" may directly stimulate the export sector.[36] This notion, however, has not so far been developed in an empirically testable model.

Similarly, it is possible to contend that the location of basic activities cannot be independently decided. This view can be substantiated on two accounts:

1. Manufacturing is losing its prime position in the export sector in larger cities. Other activities are less location-bound and depend more upon the efficient-linkages with other activities.
2. With technological advances, even the manufacturing activities are becoming less and less location bound.

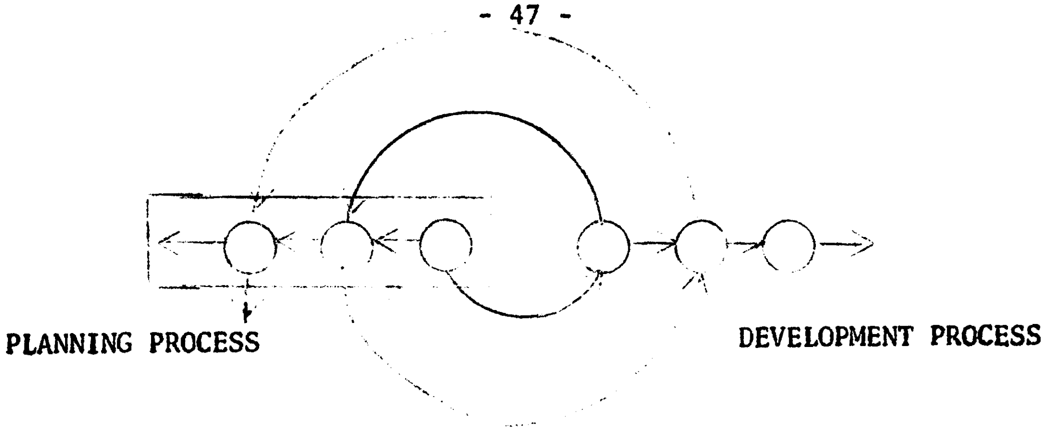
It is evident that subscribing exclusively to either the "demand model" or the "supply model" would not provide satisfactory theoretical grounds for evolving either the economic growth policy for the New Town or its physical plan.

Before stretching this point further, it may be appropriate to reconsider the various planning approaches. This can best be accomplished by using a popular analogy to medical science.

1. Remedied Planning: Planning can deal only with perceived problems. Its function is to solve these problems and must proceed as "disjointed incrementalism".
2. Anticipatory or Preventive Planning: Planning should not only deal with present problems, but also with future problems. Planning should take action today to avoid tomorrow's problems.
3. Promoting healthy growth: The aim of planning should not be defined by absence of problems but by certain norms to be achieved. Planners have all along been fascinated by this approach. Planning of New Towns has therefore been conceived by planners as an opportunity to follow this approach, since the task of planning a new town apparently is less inhibited by problem solving purposes.

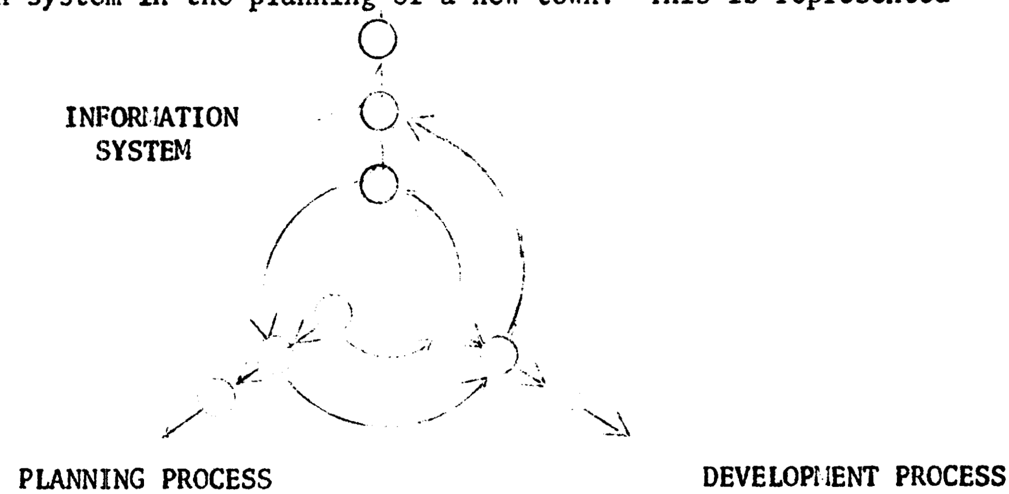
This ideological approach to planning of new towns is in contrast with the proliferation of analytical tools which heavily lean on a "demand model" which creates problems in planning and development of the New City. The models developed so far identify certain variables and try to estimate the parametric values that describe the interrelation between the variables based upon past data. (Here too cross-sectional bias is the rule rather than the exception in these models.[37]). The models then project the values of these variables by assuming that the parametric values remain constant. But the purpose of planning is essentially to bring avout changes in parametric values, which represent processes as against stocks. Moreover, in the case of the New Town there is no prior system which can be observed and projected in future. The ideologically normative planning, on the other hand, attempts to place the new town as a single product in the market. This is clearly not an appropriate proposition especially in the case of large New Towns which are not single-industry company towns.

In the case of New Towns that are expected to have a diversified industrial base and are to be developed over a long period of time, it is not advisable to have a frozen plan that covers the entire span of time. Although it is possible to sell the idea of a New Town as a whole, it is certainly not feasible to sell its concrete form as a whole. The New Town needs to be put on the market as a series of partial schemes. The market responses to the initial scheme need to be taken into account in the subsequent schemes. These market responses are not only confined to economic responses but involve a wide spectrum of human, social, and political responses in the case of a new town. This process is shown diagramatically.



It should be noted that the sequence of schemes (shown in the box in the diagram) or decisions cannot be derived from a predetermined "master plan". It has to evolve from the incorporation of responses. The straight lines in the diagram indicate that the planning action and market responses are dependent upon the preceding planning action or market response respectively. The curved lines indicate the influences of planning actions and market responses on each other. This approach, if followed in its extreme form, encounters another danger. Planning of New Towns usually has a broad goal often defined at the regional level, e.g., to help divert the future growth of the metropolis in the vicinity. Extreme submission to market responses may cause a deviation from this goal.

There is apparently no theory which includes the valid elements of a demand model and supply model which would help simulate this process of interdependent sequences of planning actions and market responses. Under these circumstances, information cannot be utilized to rationalize the planning action. The decision making will essentially remain heuristic. The information system can evaluate the consequences of the planning decisions. This could be accomplished by comparing 'what has actually happened as a result of market responses' with 'what was believed to happen'. Such comparison helps assess the effectiveness of means available to the planning system to achieve certain objectives. Such assessment of the effectiveness of the 'means' should form an important input to the subsequent planning actions. This is the role, analogous to that of an intelligence center, that can be played by an information system in the planning of a new town. This is represented below:



Apart from aiding the cybernetic control of the development of the New Town, the urban information system presents some other opportunities. In the case of existing towns, the administrative setup is more attuned to have information generated within each department. Much of the information processing is imbedded in the decisions made by lower level management and is not explicit. In such a set-up, individual departments are reluctant either to use information from other departments or to make available their information to the rest of their counterparts. Planning, which essentially uses information generated in other departments, suffers a lot in such a set-up. Instituting an information system right from the beginning affords an opportunity to build up an executive set-up which allows integration of planning and administration. It may be appreciated that the success of an information system does not intrinsically depend upon its own qualities, but largely depends upon the characteristics of the environment that uses it.

". . . However, the researchers discovered that improvement of information and decision processes requires simultaneous improvement of information and decision processes requires simultaneous improvement in several related dimensions of the governmental system. The key reason for these concomitant requirements is that, given the nature of systems, improvements must reach a critical mass in order to influence the aggregative working of the system. Thus, a systems approach to urban information system development requires a simultaneous improvements aimed at: (1) integrating information technology and decision process, (2) realigning organizational structure, (3) developing personnel, (4) expanding the stock of knowledge about information systems, and (5) altering the social milieu in which the information systems are built."[38]

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